The U.S. GOVERNMENT

IS ABSOLVED

FROM ANY LITIGATION WHICH MAY

ENSUE FROM THE CONTRACTORS IN-

FRINGING ON THE FOREIGN PATENT

RIGHTS WHICH MAY BE INVOLVED.

RFEL - C

1329

A.T.I.

31420

UNCLASSIFIED

31420

The Effect of Pointer Alignment on Check Reading of Engine Instrument Panels

(None)

Warrick, M. J.; Grether, Walter F.
Engineering Division, A.M.C.

MCREXD-694-17

(Not known)

(None)

June '48	Unclass.	U.S.	Eng.	33	photos, tables, graphs

An investigation was conducted to determine the effect of various pointer alignment position on the speed and accuracy of check reading a rectangular arrangement of 16 aircraft instruments. The results indicate that it is advantageous, in terms of speed and accuracy, to have all the pointers on an instrument panel aligned to the same position, rather than have each instrument panel aligned to slightly different positions. The alignmetnent of all pointers was checked and responded to with an average of approximately 0.8 sec, while in a mixed alignment the time was approximately 1.6 sec. The judgement of the meaning of an instrument deviation will be somewhat more rapid and accurate with pointer alignment in the 9 or 12 o'clock position than in the 3 o 'clock position. The 9 o 'clock position appears to be slightly superior to the 12 o 'clock position.

Copies of this report may be obtained only by U.S. Military Organizations.

Aviation Medicine (19) Instruments - Reading errors (52072)

ATI No. 31420

MEMORANDUM REPORT

U. S. AIR FORCE
AIR MATERIEL COMMAND
WRIGHT-PATTERSON AIR FORCE BASE
DAYTON, OHIO

NUMBER MCREXD-694-17 4 JUNE 1948

THE EFFECT OF POINTER ALIGNMENT ON CHECK READING OF ENGINE INSTRUMENT PANELS

AERO MEDICAL LABORATORY
ENGINEERING DIVISION

Hq AMC Form No. 90-34C
(24 Jun 47)

WF-(B)-O-27 JUL 48 230

U. S. ARMY AIR FORCE
HEADQUARTERS, AIR MATERIEL COMMAND
ENGINEERING DIVISION

No of pages - 33

MC REXD-9/MJW/mec

MEMORANDUM REPORT ON

Date: 4 June 1948

SUBJECT: The Effect of Pointer Alignment on Check Reading of Engine Instrument Panels

SECTION: Aero Medical Laboratory

SERIAL NO.: MC REXD-694-17   Expenditure Order No. 694-27

A. PURPOSE:

1. This investigation was conducted to determine the effect of various pointer alignment positions on the speed and accuracy of check reading a rectangular arrangement of sixteen aircraft engine or similar instruments.

B. FACTUAL DATA:

2. This investigation was initiated as a result of Memorandum Report TSEPE-655-14B in which the Instrument and Navigation Branch of the Equipment Laboratory proposed that the Aero Medical Laboratory investigate the psychological factors influencing speed and accuracy of check reading a rectangular arrangement of small size aircraft engine instruments. Investigation of pointer alignment was chosen as the first problem to be studied; other design factors will be studied subsequently.

3. Four experiments were conducted using a panel of sixteen simulated aircraft engine instruments 1 3/4 inches in diameter, mounted in a fixed Link trainer fuselage. When the panel was exposed, individuals were required to check read the panel and take appropriate action by positioning one or more toggle switches. Six pointer alignment positions were examined, alignment at the cardinal 9, 12, and 3 o'clock positions, and mixed alignment about each of these positions. Two types of test situations were used. In one situation the subject merely indicated whether or not there was deviation of any instrument. In the other situation each subject was required to identify any deviating instrument and the direction of deviation from a desired reading. The details of these experiments and their results are reported in Appendix 1.

4. The major findings of these experiments were that:

a. A rectangular group of 16 simulated engine instruments with horizontal alignment of all pointers was checked and responded to with an average time of approximately .8 seconds. A mixed alignment such as might be encountered under some flight conditions if the instruments were not rotatable was similarly checked in approximately 1.6 seconds.

b. When identification of the misaligned instrument and also judgment of whether the function had increased or decreased was required, the total response time was approximately 3.0 seconds under the most favorable condition of uniform alignment at the 9 o'clock position. The comparable time for a mixed alignment condition was approximately 5.1 seconds.

c. The judgment of whether a deviating instrument represented an increase or decrease from a desired reading was made somewhat more rapidly and accurately for alignment at the 9 and 12 o'clock dial positions than at the 3 o'clock position.

C. CONCLUSIONS:

5. The following conclusions are drawn from the results of the series of experiments described in this report.

a. The rectangular arrangement of small engine instruments on multi-engine aircraft, as proposed by the Equipment Laboratory, will result in favorable speed and accuracy in check reading of engine instrument panels.

b. The use of rotatable instruments or rows of instruments, making possible uniform pointer alignment under any flight condition, will provide a significant advantage in speed and accuracy of check reading, although this advantage may be outweighed by the mechanical difficulties or other objectionable features of such adjustment provisions.

c. The judgment of the meaning of an instrument deviation will be somewhat more rapid and accurate with pointer alignment in the 9 or 12 o'clock positions than in the 3 o'clock position. The results suggest further that the 9 o'clock position is slightly superior to the 12 o'clock position.

D. RECOMMENDATIONS:

6. The following recommendations are made as a result of this study for action to be taken by the Engine Instrument Unit of the Equipment Laboratory:

a. That the development of engine instrument panels using small instrument dials with rectangular arrangement of instruments be continued for application to future multi-engine aircraft.

b. That the instruments for use in such engine instrument panels be designed for horizontal pointer alignment in the 9 o'clock position at the operating condition under which speed of check reading is judged to be most critical.

c. That special consideration be given to the possible use of rotatable instruments making possible uniform pointer alignment under all flight conditions.

Engin. Div. MR #MCREXD-694-17
4 June 1948

Prepared by: Melvin J. Warrick
MELVIN J. WARRICK
Psychology Branch

Prepared by: Walter F. Grether
WALTER F. GRETHER, Ph. D.
Psychology Branch

Approved by: Paul M. Fitts
PAUL M. FITTS, Ph. D.
Chief, Psychology Branch

Approved by:
A. P. GAGGE, Lt Col, MSC
Chief, Aero Medical Operations

Approved by:
EDWARD J. KENDRICKS, Col, MC
Chief, Aero Medical Laboratory

Concurrence: Paul T. Geiger

Appendix I

The Effect of Pointer Alignment Position on Check Reading of Engine Instrument Panels

A. Introduction:

The Instrument and Navigation Branch of the Equipment Laboratory, AMC, Wright-Patterson Air Force Base, proposed in their Memorandum Report No. TSEPE-655-1478, dated 29 November 1946, that the Psychology Branch of the Aero Medical Laboratory investigate the psychological factors which influence the speed and accuracy of check reading a panel of aircraft engine or similar instruments. This proposal originated from the activity of the Instrument and Navigation Branch in developing small single instruments to indicate engine functions. These small single instruments have an apparent advantage over the larger dual instruments in that each instrument indicates only one function for one engine. Furthermore, the small instruments offer advantages in terms of the space required on the instrument panel and in terms of maintenance.

With a major physical redesign of aircraft instruments, it is obviously desirable to incorporate in the new instruments as many features as possible that will aid the human operator in using these instruments adequately. The research reported herein is an attempt to evaluate only one of many such possible modifications.

It has been pointed out in Aero Medical Laboratory Memorandum Report No. TSEAA-694-8B that aircraft instruments serve for three basic types of reading: (1) check reading - for assurance of a null, normal or desired indication; (2) qualitative reading - for the meaning of a deviation from a null or normal condition; and (3) quantitative reading - for the actual numerical value of an indication. The relative operational importance of these functions must be kept in mind as criteria against which to evaluate particular aircraft instruments or groupings of aircraft instruments.

In the case of aircraft engine instruments, it seems extremely important that the instruments be most adequate for the first two types of reading - check and qualitative. In other words, it is imperative that the instruments be so designed and arranged that an operator can check them very rapidly and return to his other duties being assured that no one of many indicators is deviating. Or, if one or more indicators are deviating, it is imperative that the operator be able to detect and identify readily the deviation in terms of engine and function, and at the same time gain an accurate impression of the direction in which the function is deviating so that appropriate corrective action may be taken.

It seems reasonable to assume that if the single-unit small aircraft engine instruments were grouped in a pattern so that all the instruments in a row present the same function, and all the instruments in a column correspond to the same engine, the identification of the particular engine and function could be accomplished easily. It also seems likely that if all the instrument pointers were aligned to the same position for any one operating condition, the detection and subsequent identification of a deviating function could be accomplished easily and rapidly. However, in addition to identifying the deviation, it is usually required that the operator obtain the correct sensing of the deviation so that the appropriate corrective action may be taken. In view of these comments and requirements, the question is raised: "To what position should the pointers on an instrument panel be aligned?"

Since one normally reads from left to right, it might appear that if the pointers were aligned horizontally, pointing to the right, i.e., to the 3 o'clock position, it would be very easy to scan the panel and detect any deviations of the instruments. However, this analysis neglects two possible influencing factors. An operator may not scan a panel of instruments in the same way that he reads lines of print and, secondly, correct sensing is a critical factor that may not be satisfied by alignment at the 3 o'clock position.

The purpose of this investigation was, therefore, to determine the effect of pointer alignment at the 9, 12, and 3 o'clock alignment positions in reference to the criteria implied in the previous discussion. In these experiments the subjects were required to identify a deviating indicator in a group of indicators and to take action based on the sensing of the deviation. The basic unit of comparison between the three pointer positions was the time taken to complete the check and accomplish the necessary action. Errors, although relatively few, were also recorded and are reported as a percentage of the number of trials.

B. Apparatus:

An instrument panel, containing sixteen 1 3/4 inch dials arranged in a 4 x 4 square pattern, was constructed so that the instrument pointers could be positioned by rotating corresponding knobs on the back of the panel. The dials and pointers were constructed to duplicate those proposed by the Instrument and Navigation Branch. (See Figure 1.) The panel was mounted in a fixed Link trainer fuselage directly in front of the operator in the position normally occupied by the trainer instrument panel. (See Figure 2.) Continuous illumination of the panel was provided by two shielded lights, one mounted on either side of the cockpit. The intensity of the illumination was adjusted to approximately 30 foot Lamberts at the panel.

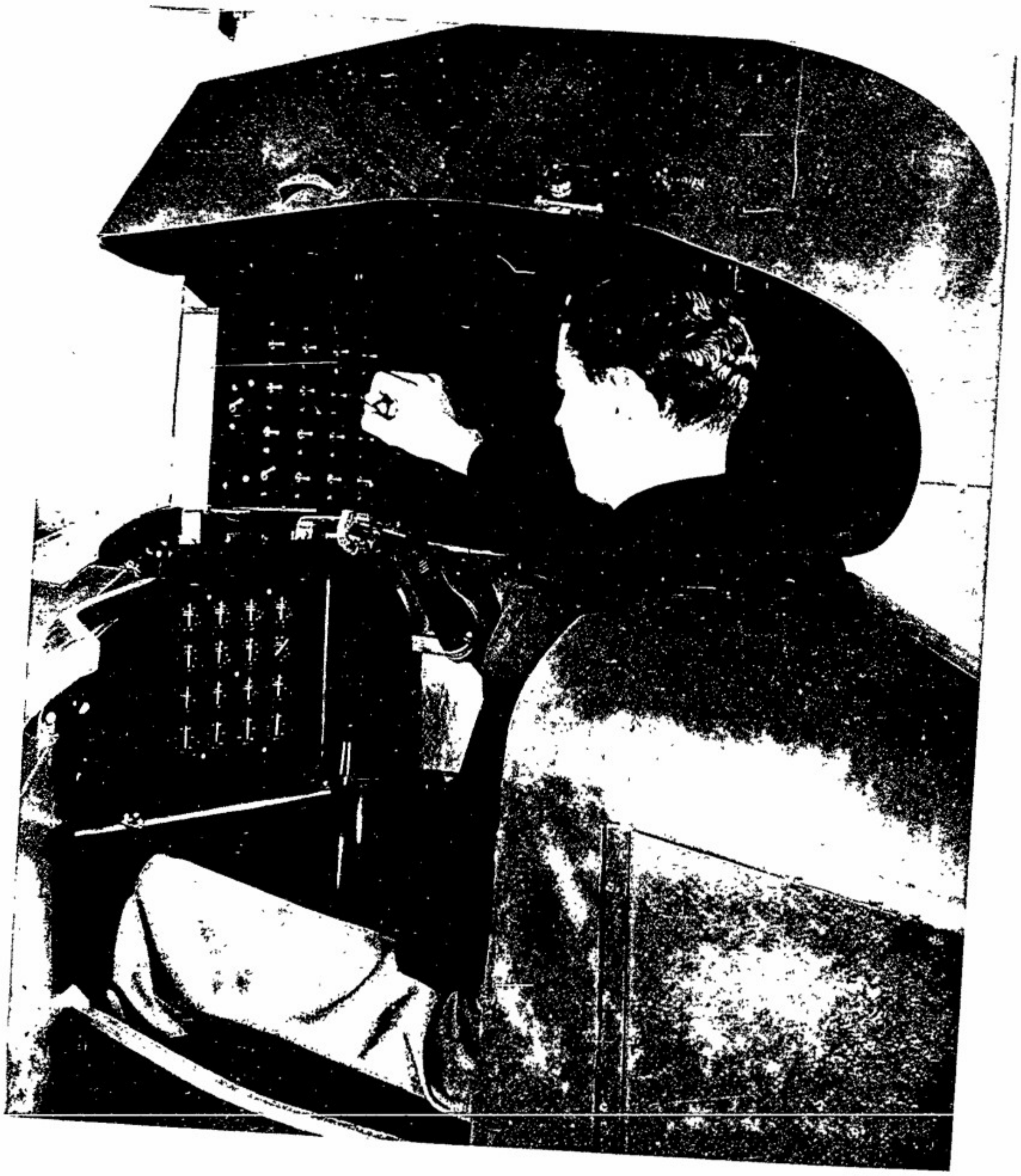

Figure 1

Subject Responding to Deviating Pointer During a Check Reading Experiment

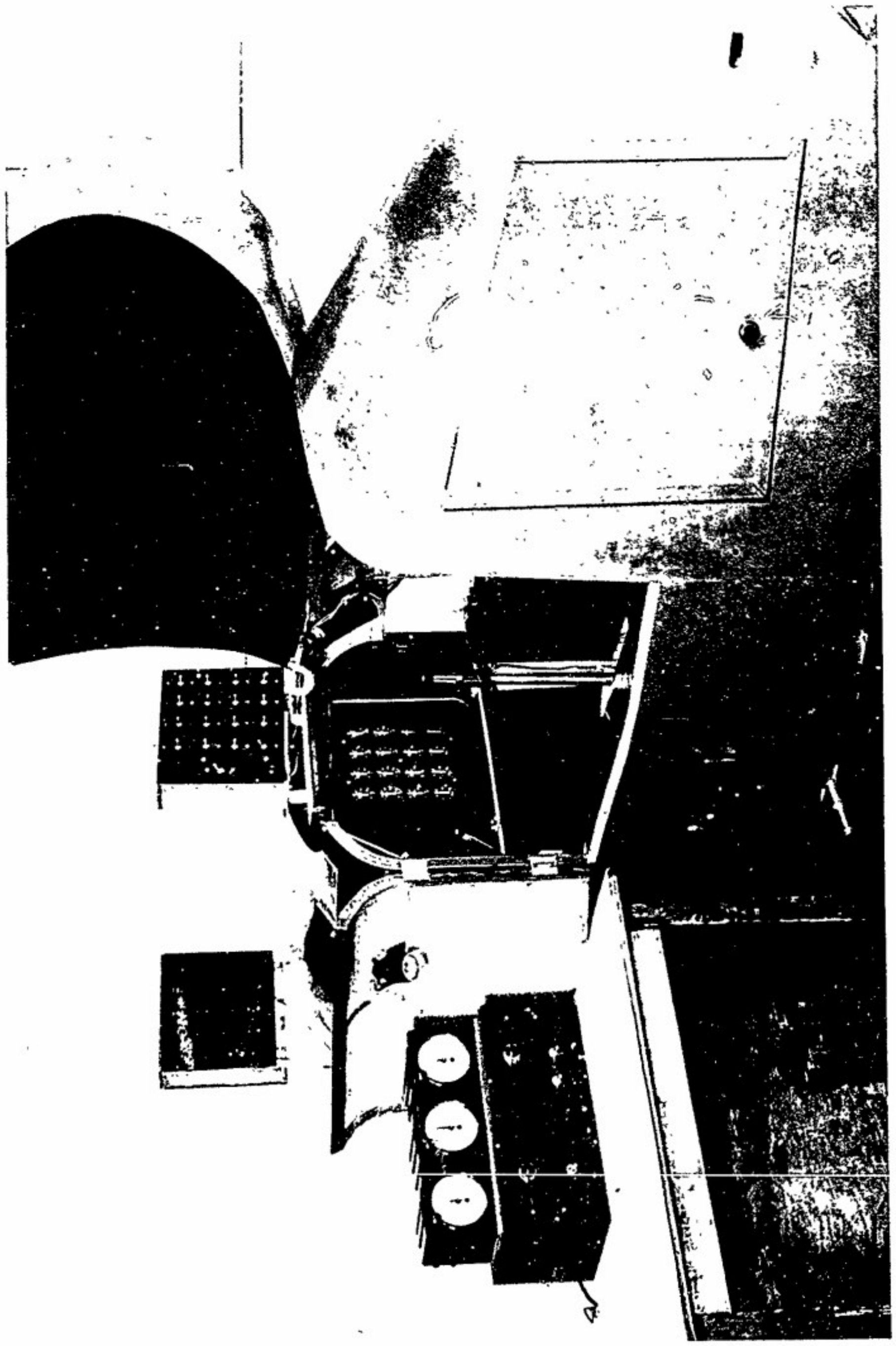

Figure 2

Apparatus Used in Check Reading Experiments

Note panel of signal lights at forward end of trainer.

The instrument panel was covered by a cloth shade mounted on a roller immediately above the panel. The instruments were exposed by raising the shade from the rear of the panel. The opening of the shade started one or more clocks which were stopped by the subject when the required response was made. As soon as the response had been made the shade was lowered, thus hiding the instrument panel from the subject while the experimenter adjusted the panel for the next trial. A subject's response panel was mounted above the instrument panel almost directly in line with the subject's eyes. It consisted of sixteen three-position toggle switches oriented vertically and arranged in a 4 x 4 square pattern duplicating the arrangement of the instrument panel. A spring return toggle switch was mounted directly to the left of the response panel. This switch was used by the subject to indicate that he had completed the check.

External to the Link cockpit there was mounted a panel of 32 indicator lights arranged in a pattern to correspond to the response switches in such a manner as to indicate to the experimenter which response switch (or switches) was operated by the subject and the direction in which it had been moved. Also external to the cockpit, were clocks inserted in the electrical circuits so as to be activated when the shade was opened and stopped when the response called for in the particular experiment was completed.

The experimenter was provided with a switch which operated a signal light inside the cockpit to notify the subject to return his response switches to the neutral position and to get set for the next trial.

During the course of a typical experiment the apparatus was operated as follows: The subject was placed in the trainer, instructed with regard to his task, and given several practice trials. He was asked to use his right hand only in responding. Fortunately none of the subjects were left-handed. Between trials he was asked to rest his hand on the control stick of the trainer and was reminded, if necessary, to do this during the practice trials. After approximately 10 practice trials, the hood was lowered and the experiment begun.

The experimenter closed the shade and made the necessary adjustments of the pointers from the rear of the panel. If a pointer was deviated from the aligned position, it was deviated by 30° so that there would be no confusion between actual deviations and some slight irregularities in the alignment of the pointers. The experimenter then signaled the subject to neutralize his toggle switches if necessary and to get set for the next trial. After a random delay, not less than 5 and not more than 15 seconds in length, the shade was opened. The subject then scanned the panel as quickly as possible and responded in accord with the instructions for the particular experiment. As soon as the subject had completed his check he depressed the completed check switch which informed the experimenter that he could now close the shade. In most instances the time lapse from the opening of the shade until the completed check response was made was taken as the criterion response time. Errors of throwing the wrong switch or of throwing a switch in the wrong direction were recorded from the indications on the experimenter's panel of lights. After each trial the subject was given knowledge of results in terms of time and errors.

C. Experiment No. 1:

Procedure. Twelve adult male subjects were used. In this and in the following experiments the subjects used were employees of the Aero Medical Laboratory, Wright-Patterson Air Force Base. These subjects had had little or no experience in check reading this type of indicator.

Three pointer alignment conditions were presented each subject, alignment at the 9, the 12, and the 3 o'clock positions. There was one and only one pointer deviating per trial. The subject's task was to locate the deviating pointer and then locate and move a corresponding toggle switch in a direction to correct the deviation; upward if the deviating instrument was reading too little and conversely. To prevent the subject from responding blindly to the pointer deviation rather than to the meaning of the deviation the subjects were required to call out "too much" if the reading on the deviating instrument was greater than the reading at the aligned position and to call out "too little" if the reading was less than the reading at the aligned position. In the later experiments (2 and 3) the subject was also required to call out "OK" if no pointers were deviating. Each subject had ten trials under each of the three alignment conditions. The order of presenting the three conditions was completely counterbalanced among the twelve subjects. Two scores were obtained: the time from the opening of the shade until the first response was made, and the total number of errors which included errors of throwing the switch the wrong way and errors of selecting the wrong switch.

Results. The results of this experiment are summarized in Tables IA, IB, and Figure 3. Pointer alignment at the 9 o'clock position resulted in more rapid and accurate check reading than did alignment at the 12 or 3 o'clock position. Note particularly that all of the subjects responded faster when the pointers were aligned at the 9 o'clock position than they did when the pointers were aligned at the 3 o'clock position, and that 11 of the 12 subjects responded faster when the pointers were aligned at the 9 o'clock position than they did when the pointers were aligned at the 12 o'clock position.

(EXPERIMENT #1, N = 12)

Table IA

Results for different pointer alignment positions for qualitative reading of 16 simulated engine instruments with one deviating pointer on each exposure.

Alignment Position	Mean Time per Response in Seconds	Percent Errors
9 o'clock	1.96	3.3
12 o'clock	2.23	4.2
3 o'clock	2.53	15.8

Table IB

Number of subjects whose average response times were faster at each alignment position as compared with each other alignment position.

9 o'clock vs*	11	12 o'clock vs**	9
12 o'clock	1	3 o'clock	3
9 o'clock vs*	12	9 o'clock vs	11
12 o'clock	0	12 o'clock vs	1
		3 o'clock	0

* Probability less than .01 of this proportion arising by chance, assuming no difference.

** Probability .05 - .10 of this proportion arising by chance, assuming no difference.

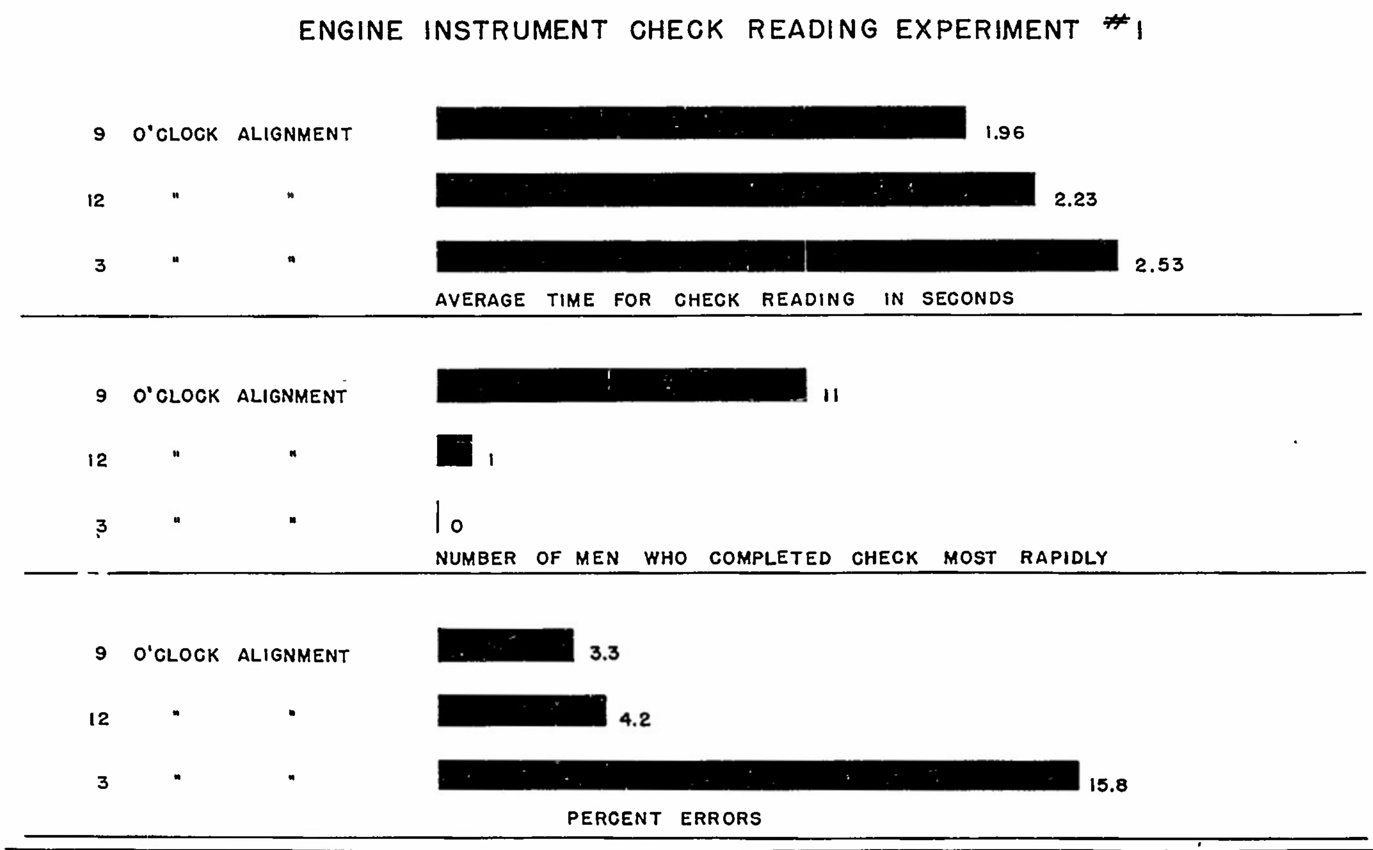

Figure 3

Speed and accuracy of checking 16 instruments with pointers aligned at the 9, 12, and 3 o'clock positions, using 12 men as subjects.

D. Experiment No. 2:

Procedure. Twelve adult male subjects were used; in part the same group as was used in Experiment No. 1. Each subject had 28 randomized trials at each alignment position, 8 trials in which no pointer deviated, 8 trials in which one pointer deviated, and 12 trials in which 2 pointers deviated from the alignment position. The order of presenting the three alignment conditions, 9, 12, and 3 o'clock, was completely counterbalanced. Each subject had two test sessions. During the first session, for one half of the subjects, the pointers were aligned at one of the cardinal positions and for the other half the pointers were aligned diagonally about the cardinal positions. In the latter case the top row of instrument pointers was aligned at a position 30° counterclockwise from the cardinal position, the second row was aligned at a position 30° clockwise from the cardinal position, the third row was aligned 30° counterclockwise from the cardinal position, and the bottom row was aligned at the cardinal position. During the second test session the conditions for the two groups were reversed. The subject was requested to check read the panel and call out the direction of the deviation or deviations, if any, then move the corresponding switch or switches in a direction to correct the error as in Experiment No. 1, and finally to depress the completed check switch. The time from opening the shade to throwing the completed check switch and the number of wrong-switch and wrong-direction errors were recorded.

Results. The results of Experiment No. 2, shown in Tables IIA, IIB, IIC, IID, and Figures 4 and 5 differ somewhat from those of the first experiment. In terms of speed of response the 9 o'clock showed only small superiority over the 3 o'clock position, and was surpassed by the 12 o'clock position. The error data showed no clear superiority of any of the three alignment positions. No entirely satisfactory explanation is apparent for the lack of agreement between the first and second experiments, although the difference in experience level of the subjects is probably a factor. Experiment No. 2 required many more test trials, and many of the subjects had previously served in Experiment No. 1. It is possible, in spite of forcing the subject to verbalize the meaning of a deviation, that some subjects responded on the basis of the physical position of the pointer only. Thus, at the 9 o'clock position the subject may have responded mechanically, "If the pointer is up, push the switch down," and vice versa, and at the 3 o'clock position, "If the pointer is up, push the switch up," and vice versa. Such a system of response would produce confusion between the responses required at the two positions and hence result in delayed response times at these two positions. For the 12 o'clock there was not this direct conflict, which may account for the more rapid response times at that position.

One finding came out very clearly in Experiment No. 2. The instrument conditions in which all pointers were aligned to the same cardinal position resulted in much more rapid responses than the mixed or diagonal alignment conditions. Under no condition did a subject respond more rapidly with diagonal alignment than he did with alignment at the cardinal positions. Uniform alignment at the cardinal positions also produced approximately one-half the errors of the mixed alignment condition.

In Experiment No. 2, as in Experiment No. 1, the subject was instructed to operate the response switches in a direction to correct the instrument deviations. Due to the possibility that this particular feature of the experiment might have favored either the 9 or 3 o'clock dial position, Experiment No. 3 was carried out with a reversed direction of switch movement.

Engin. Div. MR #MCREXD-694-17
4 June 1948

(EXPERIMENT #2, N = 12)

Table IIA

Results for cardinal pointer alignment for qualitative reading of 16 simulated engine instruments with varying number of deviating pointers.

Mean Time per Response in Seconds

Alignment Position	No Deviating Pointer	One Deviating Pointer	Two Deviating Pointers	All Conditions Combined
9 o'clock	1.87	3.10	3.70	3.01
12 o'clock	1.42	2.69	3.40	2.63
3 o'clock	1.53	3.36	3.82	3.03

Table IIB

Results for diagonal or mixed pointer alignment for qualitative reading of 16 simulated engine instruments with varying number of deviating pointers.

Mean Time per Response in Seconds

Alignment Position	No Deviating Pointer	One Deviating Pointer	Two Deviating Pointers	All Conditions Combined
9 o'clock	3.22	5.15	6.23	5.06
12 o'clock	2.96	5.19	6.14	4.96
3 o'clock	3.27	5.50	6.81	5.42

Table IIC

Number of subjects whose average response times were fastest at each alignment position as compared to each other alignment position.

	Pointers aligned at cardinal positions	Pointers aligned diagonally
9 o'clock vs	3**	4
12 o'clock	9	8
9 o'clock vs	7	6
3 o'clock	5	6
12 o'clock vs	11*	9**
3 o'clock	1	3
9 o'clock vs	3	3
12 o'clock vs	8	7
3 o'clock	1	1

* Probability less than .01 of this proportion arising by chance, assuming no difference.

** Probability .05 - .10 of this proportion arising by chance, assuming no difference.

Table IID

Percent errors of various types with cardinal alignment.

Alignment Position	Sensing Errors	Wrong Switch Errors	Failure to Note All Deviations	Total
9 o'clock	3.9	2.1	1.5	7.5
12 o'clock	3.0	2.4	2.1	7.5
3 o'clock	4.5	4.2	1.8	10.4

Percent error of various types with diagonal alignment.

Alignment Position	Sensing Errors	Wrong Switch Errors	Failure to Note All Deviations	Total
9 o'clock	8.3	2.4	5.1	15.8
12 o'clock	10.1	6.0	6.6	22.6
3 o'clock	4.2	3.6	7.2	14.9

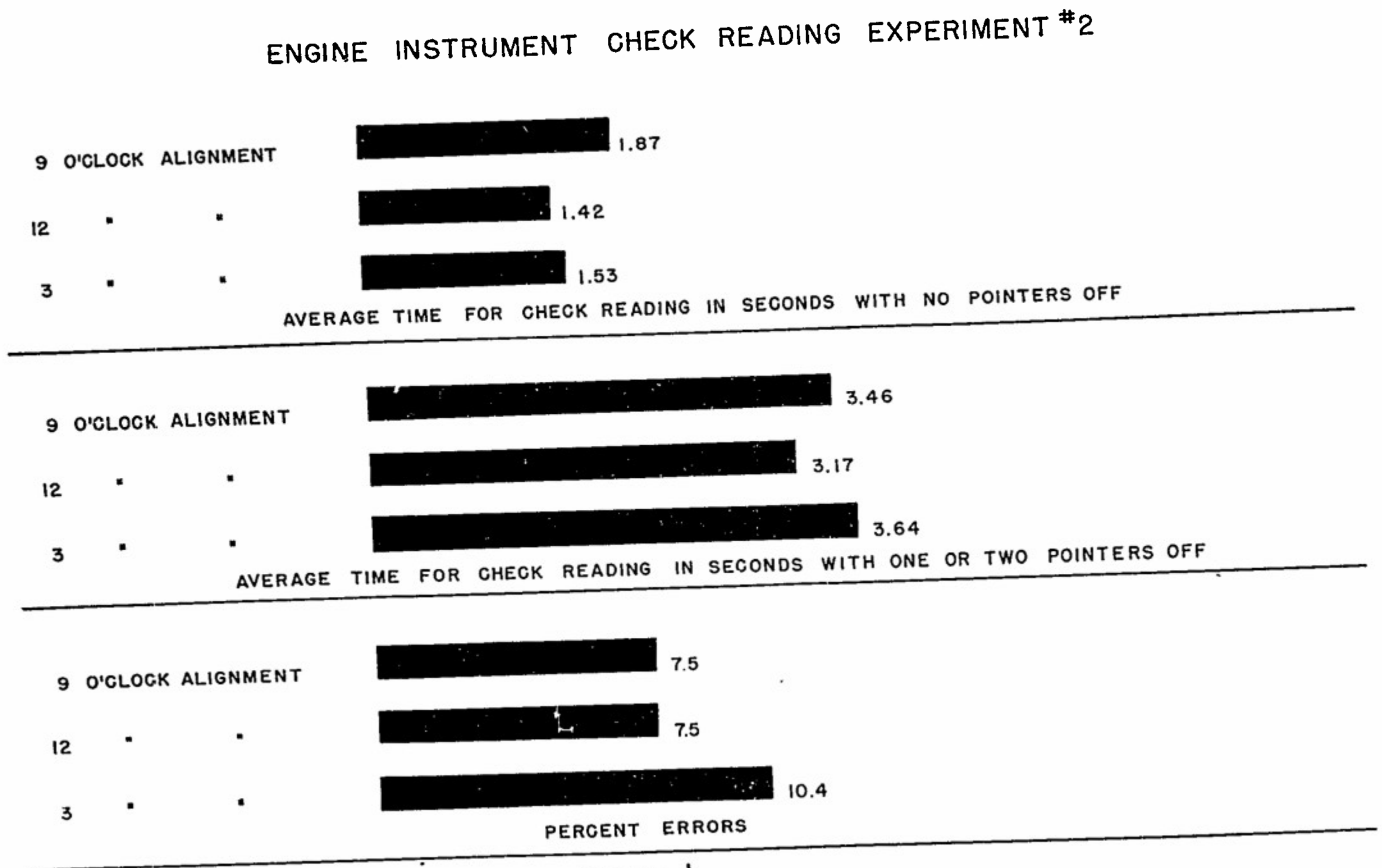

Figure 4

Speed and accuracy of checking 16 instrument with pointers aligned at the 9, 12, and 3 o'clock positions, using 12 men as subjects.

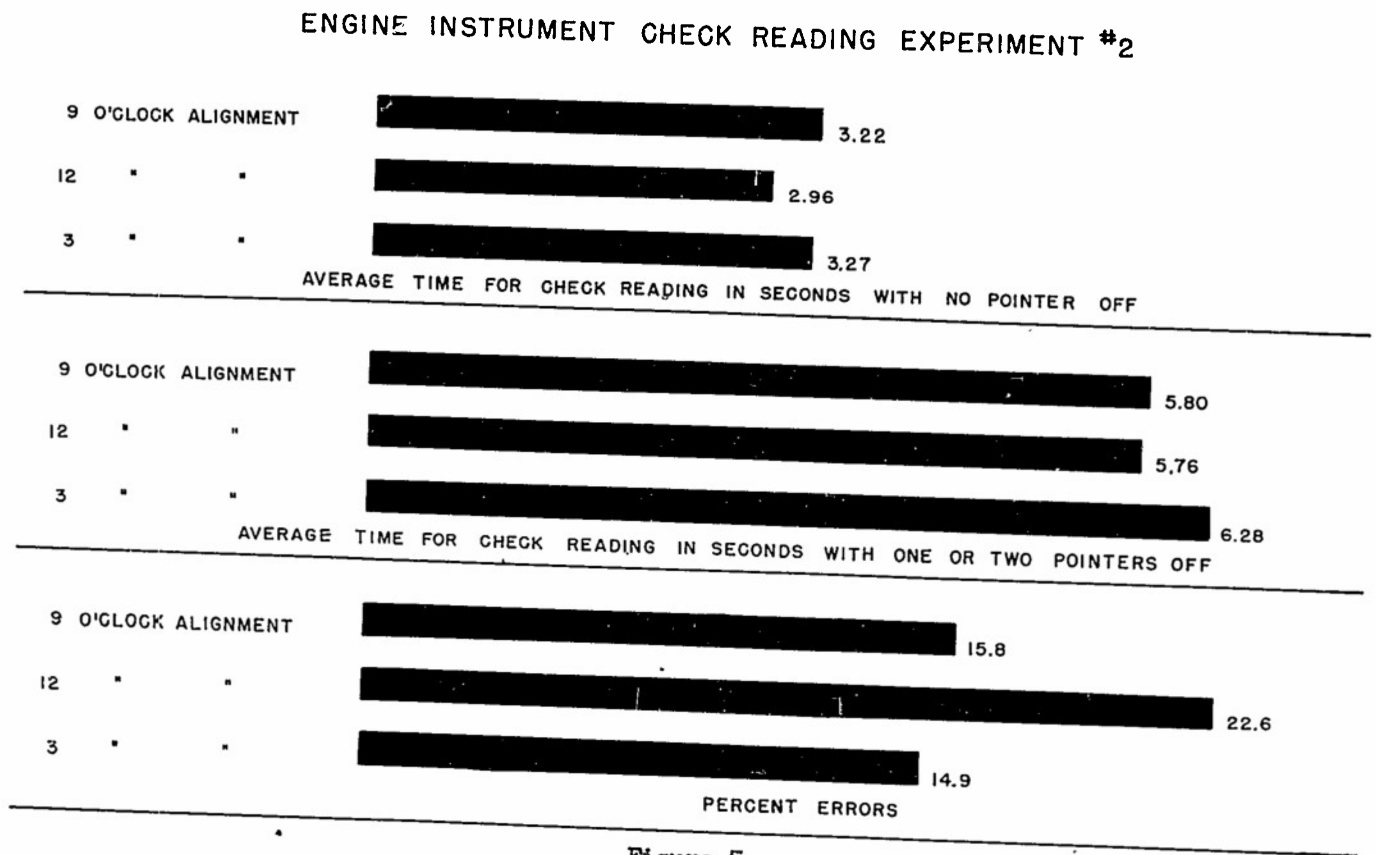

Figure 5

Speed and accuracy of checking 16 instruments with pointers aligned diagonally around 9, 12, and 3 o'clock positions, using 12 men as subjects.

E. Experiment No. 3:

Procedure. This experiment was exactly like Experiment No. 2, with the following exceptions:

a. The subjects were instructed to throw the switch up (instead of down) when they observed that the corresponding indicator was reading too much (clockwise deviation) and vice versa. In other words, the subject indicated the sensing of the deviation rather than the sensing of the corrective response.

b. Only the aligned condition, i.e., alignment at precisely the 9, 12, and 3 o'clock position, was examined.

c. Only six subjects were used. Counterbalancing of the alignment position was employed.

Results. The results of this experiment shown in Tables IIIA, IIIB, IIIC, and Figure 6 do not indicate a definite superiority of any of the three alignment positions examined. As in the first two experiments, the 3 o'clock alignment position appears to be somewhat inferior, in terms of speed and accuracy, to the other two positions. A comparison of this experiment with Experiment No. 2 reveals that the instructions to throw the response switch so as to indicate the direction of the deviation increased both the time per response and the number of sensing errors.

(EXPERIMENT #3, N = 6)

Table IIIA

Results for qualitative reading of 16 simulated engine instruments with reversed direction of response switch movement.

Mean Time per Response in Seconds

Alignment Position	No Deviating Pointer	One Deviating Pointer	Two Deviating Pointers	All Conditions Combined
9 o'clock	2.48	4.00	4.65	3.84
12 o'clock	2.00	3.50	4.36	3.44
3 o'clock	2.32	4.38	5.20	4.15

Table IIIB

Number of subjects whose average response times were fastest at each alignment position as compared to each other alignment position.

9 o'clock vs	2
12 o'clock	4

12 o'clock vs	5
3 o'clock	1

9 o'clock vs	4
3 o'clock	2

9 o'clock vs	2
12 o'clock vs	4
3 o'clock	0

Probability of any of the above proportions occurring by chance, assuming no difference, is greater than .05.

Engin. Div. MR #MCREXD-694-17
4 June 1948

Table IIIC

Percent errors of various types

Alignment Position	Sensing Errors	Wrong Switch Errors	Failure to Note All Deviations	Total
9 o'clock	9.5	3.0	10.7	23.2
12 o'clock	14.3	3.6	13.7	31.5
3 o'clock	22.0	4.2	9.5	35.8

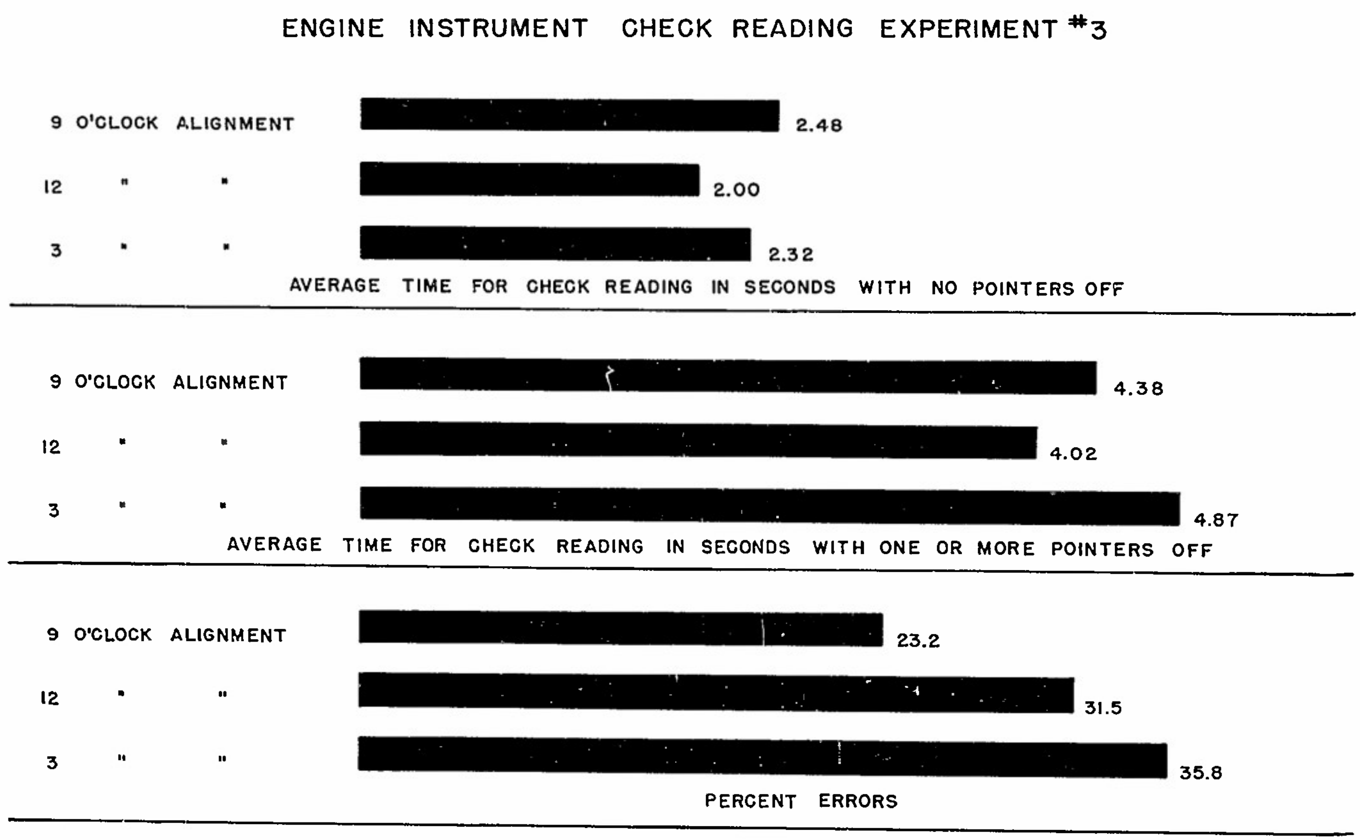

Figure 6

Speed and accuracy of checking 16 instruments with pointers aligned at the 9, 12, and 3 o'clock positions, using 12 men as subjects.

F. Experiment No. 4:

Procedure: Eight adult male subjects were used. The subjects were required to check the instrument panel as rapidly as possible after the shade was opened and to determine whether or not any instrument pointers were deviating from the aligned position. This represented simple check reading rather than qualitative reading as in the first three experiments. Half of the subjects responded by moving a lap-held, three-position toggle switch to the right to indicate no deviating pointer, and to the left to indicate a deviating pointer. The other half of the subjects followed the alternate instruction.

The subjects were allowed all the time they wished to complete the check. Their score was taken as the time from opening the shade until the correct response was made. Hence, the errors recorded were incorrect initial responses that were later corrected.

Each subject was given a total of twenty trials at each alignment position. In ten of the trials all pointers were aligned. In ten of the trials one pointer was deviated. Each subject was tested at each alignment position, 9, 12, and 3 o'clock, with all the pointers aligned at the cardinal positions and at each alignment position with the pointers aligned diagonally about the cardinal position as in Experiment No. 2. The order of trials was randomized and the testing order of the three conditions was counterbalanced.

Results. Tables IVA, IVB, IVC, and Figures 7 and 8 present the results of Experiment No. 4. The results do not indicate any clear superiority of any one of the three alignment positions for simple check reading where the direction of the deviation is ignored. This experiment, as does Experiment No. 2, demonstrates the tremendous advantage for check reading of having all the indicators aligned to the same cardinal position. Under no condition did a subject respond more rapidly when the pointers were aligned diagonally than he did when they were aligned to cardinal positions. It should be noted that with pointer alignment, these subjects could check read an instrument panel consisting of 16 instruments and detect a deviation in an average time of less than 0.8 seconds.

Engin. Div. MR #MCREXD-694-17
4 June 1948

(EXPERIMENT #4, N = 8)

Table IVA

Results for simple check reading of 16 simulated engine instruments with pointers aligned at cardinal positions.

Mean Time per Response in Seconds

Alignment Position	No Deviating Pointer	One Deviating Pointer	All Conditions Combined	Percent Errors
9 o'clock	.77	.74	.75	14.4
12 o'clock	.73	.78	.76	15.0
3 o'clock	.79	.75	.77	8.1

Table IVB

Results for simple check reading of 16 simulated engine instruments with diagonal or mixed pointer alignments.

Mean Time per Response in Seconds

Alignment Position	No Deviating Pointer	One Deviating Pointer	All Conditions Combined	Percent Errors
9 o'clock	1.75	1.54	1.64	18.8
12 o'clock	1.55	1.57	1.56	15.6
3 o'clock	1.82	1.48	1.59	10.6

Table IVC

Number of subjects whose average response times were fastest at each alignment position as compared with each other alignment position.

	Pointer aligned at cardinal positions	Pointers aligned diagonally
9 o'clock vs	4	2
12 o'clock	4	6
9 o'clock vs	5	5
3 o'clock	3	3
12 o'clock vs	4	5
3 o'clock	4	3
9 o'clock vs	2	2
12 o'clock vs	3	5
3 o'clock	3	1

Probability of any of the above proportions occurring by chance, assuming no difference is greater than .05.

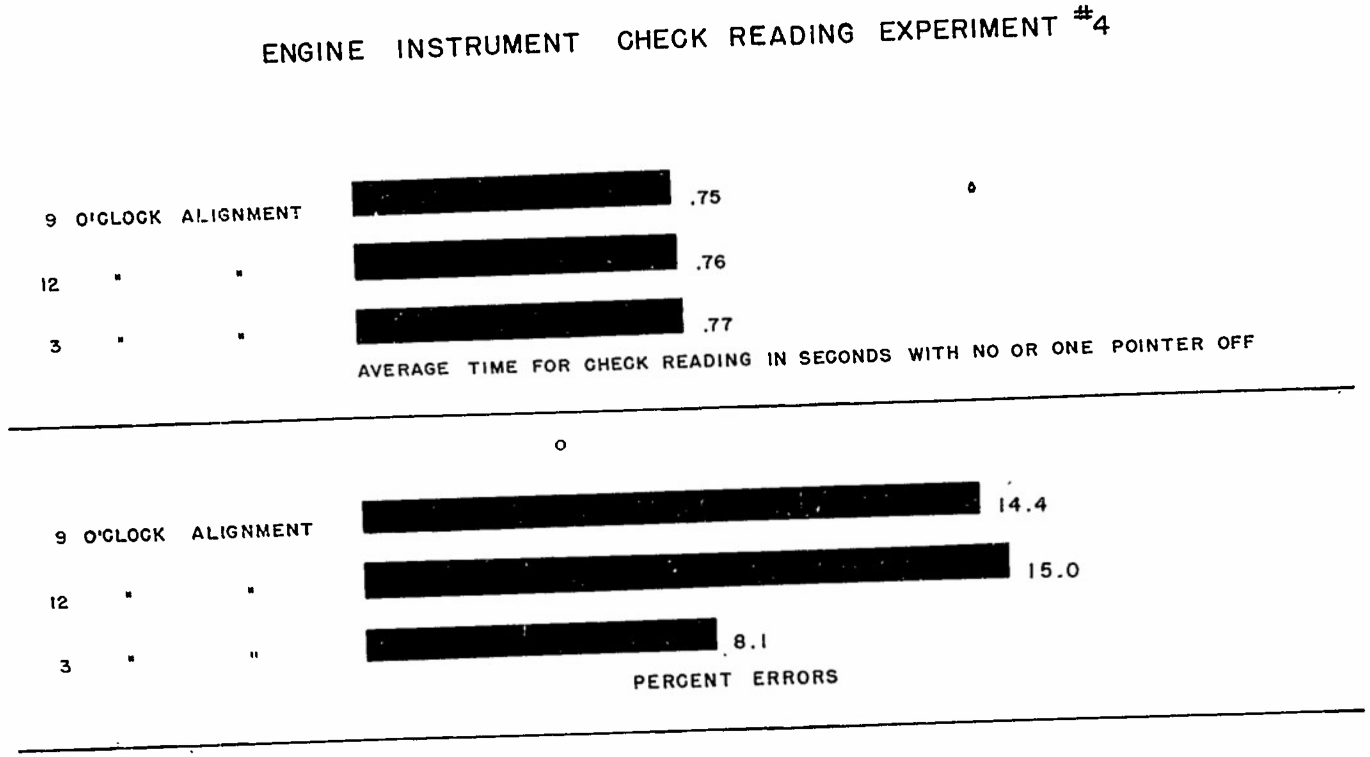

Figure 7

Speed and accuracy of checking 16 instruments with pointers aligned at the 9, 12, and 3 o'clock positions, using 8 men as subjects.

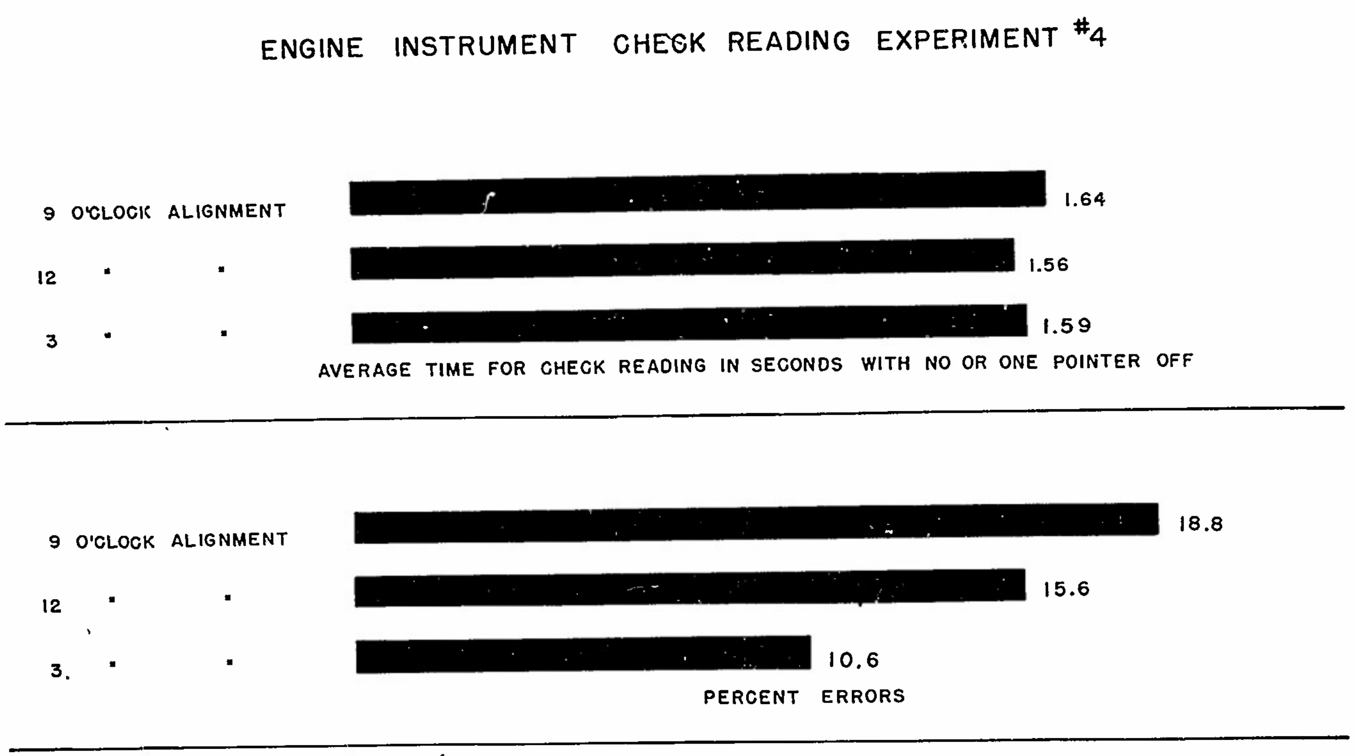

Figure 8

Speed and accuracy of checking 16 instruments with pointers aligned diagonally around 9, 12, and 3 o'clock positions, using 8 men as subjects.

G. Interpretation of Results and Application to Instrument Design:

The foregoing experiments clearly demonstrated that the use of horizontal or vertical pointer alignment greatly simplifies the task of check reading a rectangular group of engine instruments. In fact, it was possible with this arrangement to check 16 instruments in approximately 0.75 sec. This is only slightly longer than the check reading time for single instruments being obtained in two other current investigations. A mixed pointer alignment condition caused approximately 100 percent increase in response time and errors.

These results, applied to the design of an engine instrument panel, indicate the desirability of using either horizontal or vertical pointer alignment. This can obviously be done for only one flight condition unless provision is made in the panel for rotating the instruments to adjust for differing instrument readings under different conditions. This could presumably be done with a suitable adjusting knob for each row of instruments. A number of practical objections can be raised to such an arrangement: (a) the mechanical complexity of the instrument mountings and panel would be increased; (b) the number of controls necessitating adjustment, which is already excessive, would be further increased; (c) not all numerals on the dial could remain upright at all times. Whether or not these objections outweigh the advantages to be gained by uniform pointer alignment is outside the scope of this investigation.

The other major finding, though less clear cut, was that the 3 o'clock alignment position was inferior to the 9 and 12 o'clock positions for judging the direction of instrument deviation. This probably resulted from the fact that at the 3 o'clock position the pointer moves down, instead of up, for increase on a conventional clockwise-increase dial. It is conventional, and probably more natural, to associate an upward movement with increase in indication. A movement to the right for increase, as at the 12 o'clock dial position, apparently is quite satisfactory.

Applied to the design of engine instrument panels, this second finding suggests that pointer alignment should be at either the 9 or 12 o'clock positions. An objection which can be raised to the 12 o'clock position is that pointer deviations beyond the top center of the dial will bring in downward movement for increase, as at the 3 o'clock position. For this reason it would seem, in agreement with Experiment No. 1, that the 9 o'clock alignment position should be best.

H. Summary and Conclusions:

Tests were made with a four by four arrangement of sixteen simulated engine instruments of 1 3/4 inch diameter to determine the effects of pointer position upon (a) the ability to detect an instrument deviation, and (b) the ability to judge the direction, increase or decrease, of the deviation. The subjects were enclosed in a Link trainer fuselage. Upon exposure of the engine instrument panel the subject responded by suitable operation of toggle switches. The speed of response and errors were recorded.

The following conclusions are indicated by the results of this investigation:

1. A group of 16 instruments with uniform horizontal or vertical pointer alignment can be checked, and an appropriate response made, in approximately 0.75 seconds.

2. The use of a mixed alignment condition approximately doubles the response time and frequency of errors in checking a group of 16 instruments.

3. The pointer alignment position, 9, 12, or 3 o'clock, has little, if any, effect upon simple check reading involving the mere detection of a deviation.

4. When check reading involves judgment of the direction of instrument deviation, the 3 o'clock alignment position is inferior to the 9 and 12 o'clock positions.

I. Summary of Results:

The results of these four experiments do not consistently indicate a marked superiority of any one of the three alignment positions examined. The time taken for check reading appears to be relatively independent of the orientation of the pointers. However, in terms of the number of subjects in each experiment working fastest at each alignment position, in only one part of one experiment was the 3 o'clock alignment position responded to as rapidly by as many subjects as were the other positions.

The total number of errors also appears to be relatively independent of the orientation of the pointers. The number of sensing errors and the number of wrong switch errors, however, is consistently (with one exception) greater at the three o'clock alignment position than at the nine o'clock alignment position. This, perhaps, indicates that alignment about the 3 o'clock position is somewhat ambiguous. In that position an increase is represented by two perhaps contradictory movements, clockwise and down. This ambiguity is not present at the 9 o'clock position since a clockwise movement of the pointer is also an up movement.

The results clearly indicate that it is advantageous in terms of speed and accuracy of check reading to have all the pointers on an instrument panel aligned to the same position rather than to have each row of instruments aligned to slightly different positions. In no case did a subject respond more rapidly under conditions of diagonal alignment than he did under conditions of cardinal alignment. The advantage of aligning all the instruments to the same position is far greater than the advantage of alignment at any one position. To illustrate this point, refer to Experiment No. 4 in which the subjects were capable of check reading the entire panel of 16 instruments in 0.8 seconds when the pointers were all aligned to the same cardinal position. However, when each row of pointers was aligned to slightly different positions the subjects required 1.6 seconds, double the time required when the pointers were all aligned to the same position.

Engin. Div. MR #MCREXD-694-17
4 June 1948

DISTRIBUTION

MCREXD (Library) (1)

MCREXD-9 (50)

MCID "Release" (2)

MCREOA-6 (1)

MCREEC-51 (1)

MCREXA-4 (1)

MCREXE-4 (1)

MCREXE-1 (1)

MCRW (2)

Cambridge Field Station
230 Albany Street
Cambridge 39, Massachusetts
ATTN: Chief, Visual Design Laboratory (1)

Office of the Air Surgeon
USAF
Washington 25, D. C.
ATTN: Psychological Section (10)

Commandant
AF School of Aviation Medicine
Randolph Field, Texas (2)

Office of the Surgeon
Headquarters Air Training Command
Barksdale Field, Louisiana
ATTN: Psychological Section (2)

Psychological Research & Examining Unit
Sqn E, Indoctrination Division
Air Training Command
San Antonio, Texas (2)

Office of the Surgeon
Strategic Air Command
Andrews Field, Maryland
ATTN: Psychological Section (2)

Air University
Maxwell Field, Alabama
ATTN: Library (1)

Medical Safety Branch
Flying Safety Division
Field Office of The Air Inspector
Langley Field, Virginia (1)

Chief of Naval Research
US Navy
Washington 25, D. C.
ATTN: Medical Sciences Division (1)

Special Devices Center
Sands Point, Port Washington
Long Island, New York
ATTN: Human Engineering Section (2)

Special Devices Center
Sands Point, Port Washington
Long Island, New York
ATTN: Flight Section (1)

Naval Research Laboratory
Anacostia Station
Washington, D. C.
ATTN: Psychological Section (2)

Bureau of Medicine & Surgery
US Navy
Washington 25, D. C.
ATTN: Aviation Psychology Section (1)

Aero Medical Equipment Laboratory
Naval Air Materiel Center
Philadelphia, Pennsylvania (1)

Engin. Div. MR #MCREXD-694-17
4 June 1948

RAF Delegation
Box 680
Benjamin Franklin Station
Washington, D. C.
ATTN: Wing Cmdr S. R. C. Nelson
(2)

Navy Electronics Laboratory
San Diego 52, California
ATTN: Dr. Arnold Small (1)

Civil Aeronautics Administration
Washington 25, D. C.
ATTN: Dr. Dean R. Brimhall,
Assistant for Research (1)

Civil Aeronautics Administration
Washington 25, D. C.
ATTN: Chief, Flight Engineering
Division (1)

Civil Aeronautics Administration
Washington 25, D. C.
ATTN: Mr. O. E. Patton
Airframe & Equipment Engineering
Division (1)

National Research Council Committee
on Aviation Psychology
University of Pennsylvania
Philadelphia, Pennsylvania
ATTN: Dr. M. S. Viteles (2)

Office of Technical Service
Department of Commerce
Washington 25, D. C.
ATTN: Chief, Bibliographic and
Reference Division (1)

Aeronautics Division
Library of Congress
Washington 25, D. C. (1)

Civil Aeronautics Board
Washington 25, D. C.
ATTN: Mr. R. V. Garrett (2)

Research & Development Board
Committee on Human Resources
1712 "G" Street, N. W.
Washington 25, D. C.
ATTN: Dr. Lyle H. Lanier (1)

Air Transport Association of
America
1107 16th Street, N. W.
Washington 6, D. C.
ATTN: Mr. Alan Dallas
Director of Engineering (1)

American Psychological Asso, Inc.
1515 Masachusetts Avenue, N. W.
Washington 5, D. C.
ATTN: Dr. Dael Wolfle (1)

Mr. R. L. McBrien
United Airlines, Inc.
Resident Repl., c/o Glenn L. Martin Co.
Baltimore, Maryland (1)

Department of Psychology
University of California
Berkeley, California
ATTN: Dr. C. W. Brown (1)

Department of Psychology
Indiana University
Bloomington, Indiana
ATTN: Dr. D. G. Ellson (1)

Department of Psychology
Lehigh University
Bethlehem, Pennsylvania
ATTN: Dr. Adelbert Ford (1)

Department of Psychology
University of Maryland
College Park, Maryland
ATTN: Dr. R. Y. Walker (1)

Department of Psychology
Princeton University
Princeton, New Jersey
ATTN: Dr. W. E. Kappauf (1)

Department of Psychology
University of Rochester
Rochester, New York
ATTN: Dr. S. D. S. Spragg (1)

Department of Psychology
Tufts College
Medford, Massachusetts
ATTN: Dr. J. L. Kennedy (1)

Engin. Div. MR #MCREXD-694-17
4 June 1948

Department of Psychology
University of Washington
Seattle, Washington
ATTN: Dr. R. B. Loucks (2)

Department of Psychology
Johns Hopkins University
Baltimore, Maryland
ATTN: Dr. C. T. Morgan (1)

Department of Psychology
University of Illinois
Urbana, Illinois
ATTN: Dr. A. C. Williams, Jr. (1)

Department of Psychology
State University of Iowa
Iowa City, Iowa
ATTN: Dr. J. S. Brown (1)

Baker Library
Harvard University
Boston, Massachusetts
ATTN: Dr. Ross A. McFarland (1)

Psychological Abstracts
Undergraduate Division
University of Illinois
Galesburg, Illinois (1)

Kollsman Instrument Division
80-08 45th Avenue
Elmhurst, Long Island, New York
ATTN: Mr. Henry Droge (1)

Bendix Aviation Corporation
Eclipse-Pioneer Division
Teterboro, New Jersey
ATTN: AF Representative (1)

Sperry Gyroscope Co., Inc.
Great Neck, Long Island, N. Y.
ATTN: AF Representative (2)